OCT 26 1981

SYSTEM OPERATING REQUIREMENTS

HAMILTON-WENTWORTH RAPID TRANSIT PROJECT

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To: The Regional Municipality of Hamilton-Wentworth

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004797

MCL Report HW-1-10
Part of Task 4.6
October 9, 1981

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1.0 SYSTEM OVERVIEW

1.1 The ICTS Concept

The Intermediate Capacity Transit System (ICTS) consists of short trains of high performance vehicles operating automatically at station headways as low as 60 seconds with a maximum line speed of 20 m/s (72 km/h). Vehicles are of a compact, lightweight design, 12.7 m in length and 2.5 m wide with a nominal capacity of 75 passengers.

Vehicles are supported on steel wheels and the trackwork is standard gauge, continuously welded rail. The guideway is a dedicated right-of-way and is usually elevated. The guideway can also be located at grade, where this is acceptable, and in tunnel sections, where essential.

ICTS is a cost-effective, safe and dependable solution to today's urban transit needs. The system has been designed specifically for integration into the urban environment and to achieve low life-cycle costs, and is suitable for a wide range of applications, with intermediate capacities up to 25,000 passengers per hour per direction.

1.2 Application To Hamilton-Wentworth Rapid Transit System

The ICTS would provide a medium capacity, rapid transit service connecting downtown Hamilton with the Central Mountain. The system would be integrated with the existing Hamilton Street Railway bus system to meet the future public transportation needs of the Region.

The Mountain Corridor would be the first link of a rapid transit system that would also serve the needs of the industrial core and future east-west transportation needs.

As configured for Hamilton, the system is designed for operation of 4-car trains and headways as low as 90 seconds. This yields an ultimate capacity in excess of 10,000 passengers per hour.

The system design is based on Canadian Urban Transit Association (CUTA) "Policy on Transportation for the Handicapped", dated March 10, 1980. See Appendix A for this document.

2.0 GUIDEWAY

2.1 General Description

The guideway is a combination of elevated, at-grade and below grade structures.

The guideway supported system elements are the power rails, the Automatic Train Control (ATC) inductive loop, the Linear Induction Motor (LIM) reaction rail, the vehicle running rails, switches with switch machines, cabling and wireways, walkway, vehicle retention walls and drainage.

The typical guideway cross-section comprises a concrete bed with direct fixation fasteners and AREA Standard 115 lb/yd running rails. The rails are typically continuously welded. Special trackwork includes spiral turnouts and moveable point frogs.

The maintenance yard trackwork is placed on concrete slab and all turnouts in the yard are of standard AREA geometry with fixed frogs.

The LIM reaction rail is mounted between the running rails, attached to the concrete bed and in the plane formed by the top surface of the running rails. The power rails are mounted typically on one side of the guideway and in a vertical plane above the level of the running rails.

The at-grade guideway is a continuously reinforced concrete pavement constructed on a subgrade bed of properly selected and densely compacted free draining granular materials. All drainage is directed away from the slab foundation.

The elevated guideway may be single lane or dual lane in configuration. It is typically constructed of precast prestressed concrete flanged box girders spanning a nominal 30 metres between columns and assembled by post-tensioning into two span continuous units. Columns may vary in height from 3.0 metres to 15.0 metres depending on the site location requirements. Other guideway configurations such as concrete double tees and composite steel/concrete girders are possible. The Study Report includes use of composite steel/concrete girders on selected portions of the alignment.

A general view of the guideway and guideway mounted equipment is shown in Figure 2.1-1.

2.2 Elevated Guideway

A general cross section of an elevated guideway, with significant dimensions, is shown in Figure 2.2-2.

The dual lane spacing is between 3.0 m and 3.5 m as illustrated in Figure 2.2-3.

In turnouts and crossovers the cross section is composed of precast beams and field cast decks, as shown in Figures 2.2-4 and 2.2-5.

The precast concrete sidewalls provide for vehicle confinement in the unlikely event of vehicle derailment. The sidewalls also serve as noise barriers and mounting locations for the power rails.

2.3 Tunnel Sections

Typical tunnel cross sections are illustrated in Figures 2.3-7 and 2.3-8.

Dry stand pipes and hose storage, tunnel to surface communication system and lighting is provided in all tunnel sections.

The choice of single versus double bore tunnels is a final design decision to be made after detailed rock investigation data is available. The study report is based on the double bore concept.

2.4 Trackwork

The trackwork is 115 lb/yd AREA rail attached to the concrete beams using direct fixation fasteners which provide resilient support of the rail. The trackwork system maximizes the use of continuously welded rail to reduce both noise and maintenance. No scheduled trackwork maintenance will be required during normal operating hours.

The trackwork/beam thermal motions are handled either by rail anchors, where they can be allowed, or by scarf type expansion joints.

The trackwork is electrically grounded at intervals along the track.

2.5 Switches

Mainline switches are directly fixed to the concrete beams. All switches are actuated by an electro-hydraulic, railroad type switch machine. Switches on the mainline are equipped with a moveable point frog, actuated by an independent machine. Heaters are provided for all track switches.

Standard American Railway Engineering Association (AREA) #8 turnouts with fixed frogs are typically used in storage and maintenance areas.

2.6 LIM Reaction Rail

The reaction rail for the ICTS linear induction motor (LIM) propulsion system is directly fastened to the concrete beam, mid-way between the running rails. The reaction rail is continuous, interrupted only in switches.

The reaction rail consists of an aluminum top cap with either solid or laminated backiron to complete the magnetic circuit. In general laminated backiron would only be used in those areas where maximum performance is essential, i.e. station acceleration/deceleration lanes or on steep grades.

2.7 Power Rails

Power rails for traction power distribution are mounted on insulator clamps attached to the guideway walls. The power rails are manufactured from extruded aluminum alloy to which is attached and sealed a wearing surface of stainless steel.

The insulator clamps contain the power rails vertically and laterally to the required tolerances but allow free longitudinal movement for expansion. The positive power rail is installed above the negative rail.

A fiberglass coverboard is positioned above the top power rail. Where necessary for personnel safety, coverboards are steppable and provided with non-slip surfaces. Guardrails near the bottom of the power rails are also compatible with the power rail concept.

The power rails are provided with heaters for winter operation.

The power rails are always located on the outside of sharp curves (i.e. less than 45 m radius), and in stations are located on the side opposite the platform, whenever possible. At switches power rails are installed on both sides of the track and on/off ramps are provided to permit engagement and disengagement of the collector shoes.

2.8 ATC Inductive Loop Cables

The inductive loop cable, located just below and to the inside of each running rail head, provides for data communication between the vehicle control centre and the vehicle.

The cables are transposed at nominal 25 metre intervals. These transpositions, or crossovers, perform a position measurement function for vehicles on the guideway. The maximum length of a single inductive loop is 3.2 km. Feed-in devices for the inductive loop are generally located at passenger stations.

2.9 Cabling Provisions

Typical cable locations on elevated and at-grade guideway are illustrated in Figure 2.9-1.

No permanent lighting is installed on the guideway but power outlets are provided at regular intervals for maintenance purposes.

2.10 Walkways

Walkways are provided throughout the system for passenger evacuation under extreme emergency conditions, and for maintenance personnel during non vehicle operating hours. Non-emergency passenger evacuation will be strongly discouraged.

Walkways are provided at the centre of all dual lane elevated guideways.

Side walkways and emergency exit provisions are provided in tunnel sections and on single lane elevated guideway sections. Where installed, single guideway walkways will be fitted with handrails.

The walkway width depends on the dual lane spacing and is a minimum 610 mm wide, clear of the vehicle

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dynamic envelope. Where necessary, walkway delineation lighting will be provided.

Access roads for emergency vehicles are associated with all guideway sections.

2.11 Guideway Drainage

The guideway has adequate provisions for draining moisture from the guideway surfaces. The drainage system on elevated guideway sections consists of scupper drains located in the deck and drainage pipes embedded in the beam and column which are connected to the storm sewer or alternatively to surface drainage. The system is also heat traced to ensure drainage in cold weather and thus to prevent damage to the guideway by freezing of rainfall or melt water.

Snow removal from elevated guideways will be achieved by maintaining trains in operation during storms to prevent build-up. During three years of winter testing at Kingston, this strategy has proven to be effective.

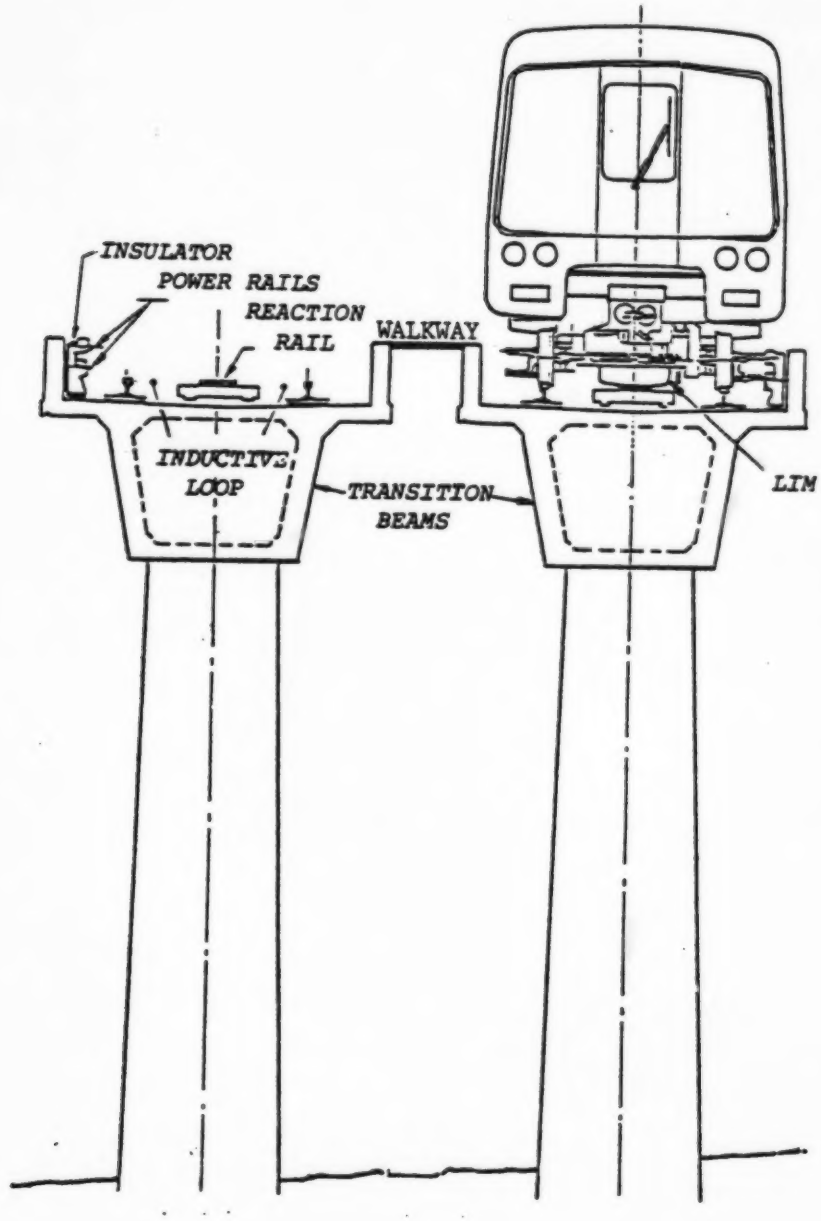


FIGURE 2.1-1

GUIDWAY AND EQUIPMENT

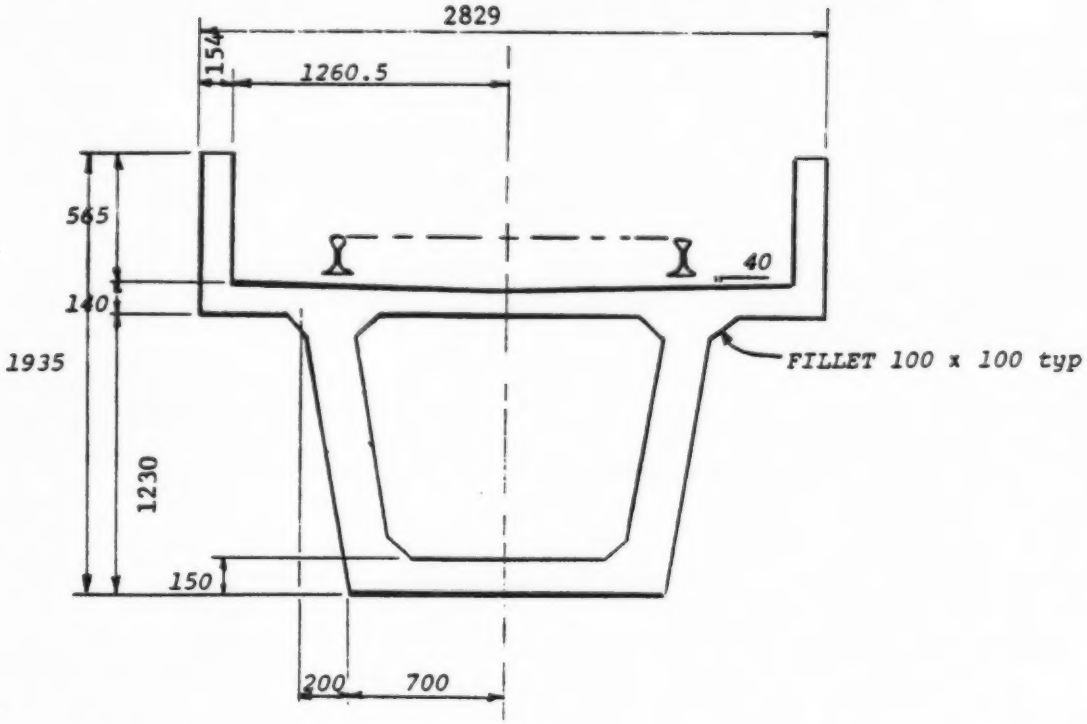


FIGURE 2.2-2

ELEVATED GUIDEWAY

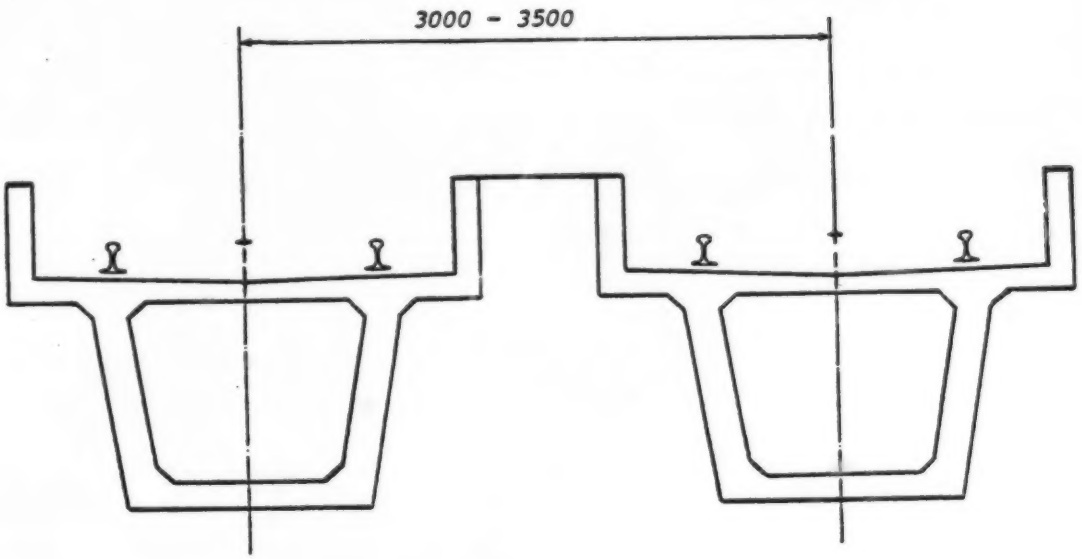


FIGURE 2.2-3

DUAL LANE SPACING

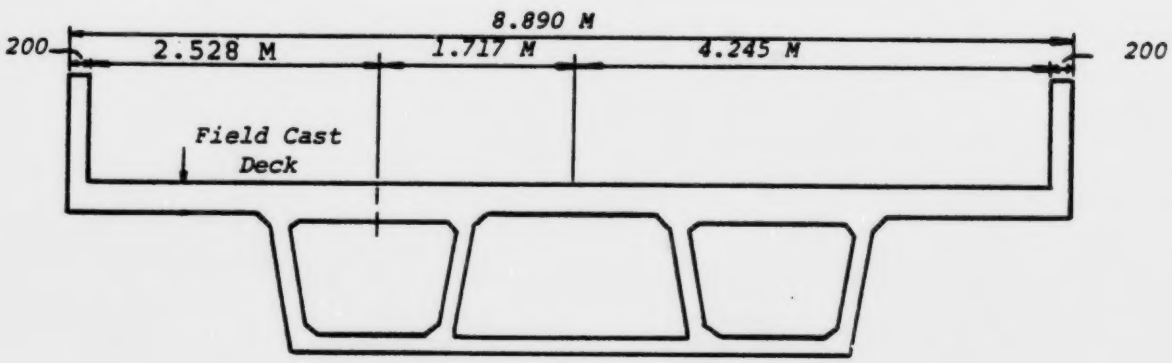


FIGURE 2.2-4

TURNOUT CROSS SECTION

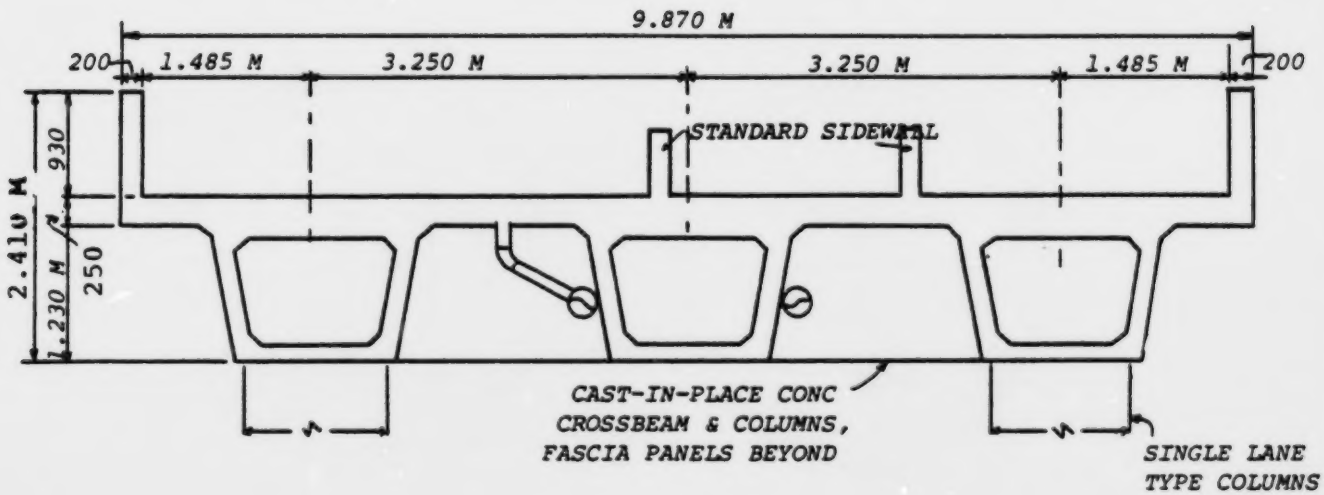


FIGURE 2.2-5

CROSSOVER CROSS-SECTION

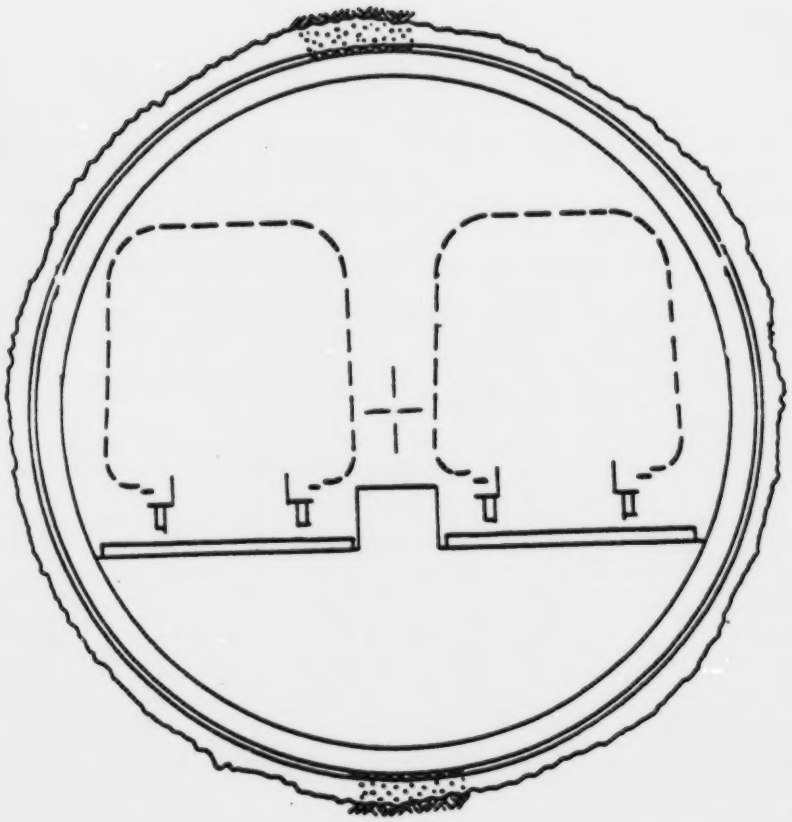


FIGURE 2.3-7

TUNNEL CROSS-SECTION (SINGLE BORE)

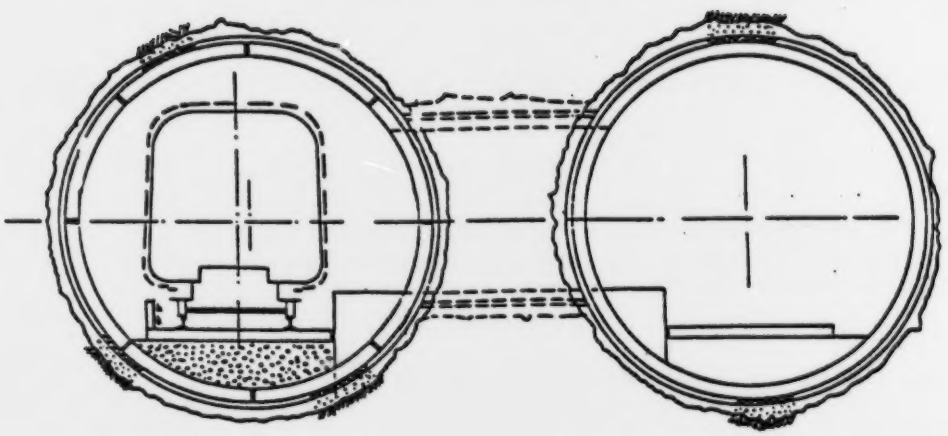


FIGURE 2.3-8

TUNNEL CROSS-SECTION (DOUBLE BORE)

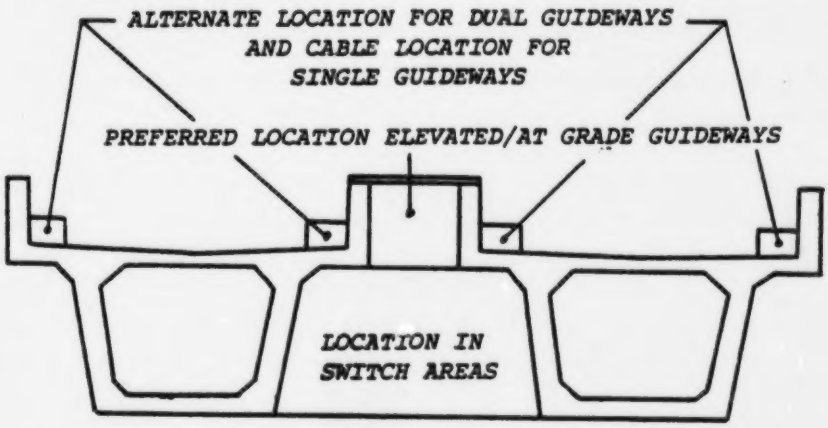


FIGURE 2.9-1

CABLE LOCATIONS

3.0 STATIONS

3.1 General Description

Passenger stations are located close to major activity centres or road intersections.

Bus and/or trolley bus stops are located at street level at all stations to permit integration of the rapid transit system with the surface bus system.

Public telephones are provided in all stations. Public washrooms are not provided. Parking spaces are not provided for passengers at the downtown stations.

Elevated stations are free-standing, structurally seperate from the guideway.

3.2 Centre Platform Stations

Centre platform stations allow passengers to conveniently board trains in either direction. The nominal track separation cannot be maintained with centre platforms however.

A typical centre platform station is shown in Figure 3.2-10.

3.3 Side Platform Stations

Side platform stations provide passengers with access to one direction of travel.

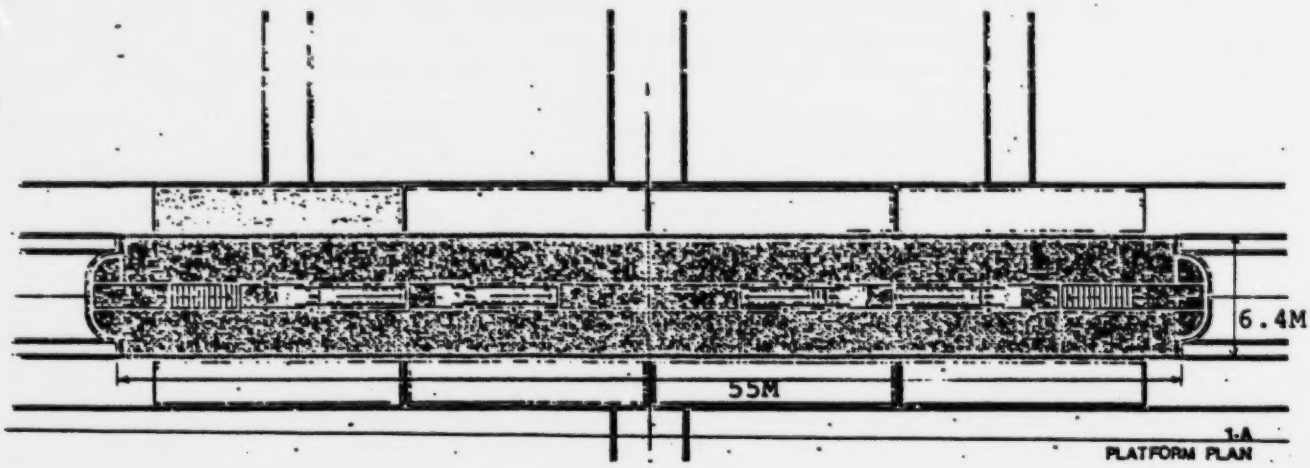
A typical side platform station is shown in Figure 3.3-11.

3.4 Platform Sizing

Station platforms are partially enclosed and designed for the ultimate capacity of the system.

The platform length is sized to accommodate a four-car train. The width of the platform is such that adequate horizontal clearance is provided between escalators, stairs, etc. and the platform edge.

Station platforms are located on nominally level tangent track.



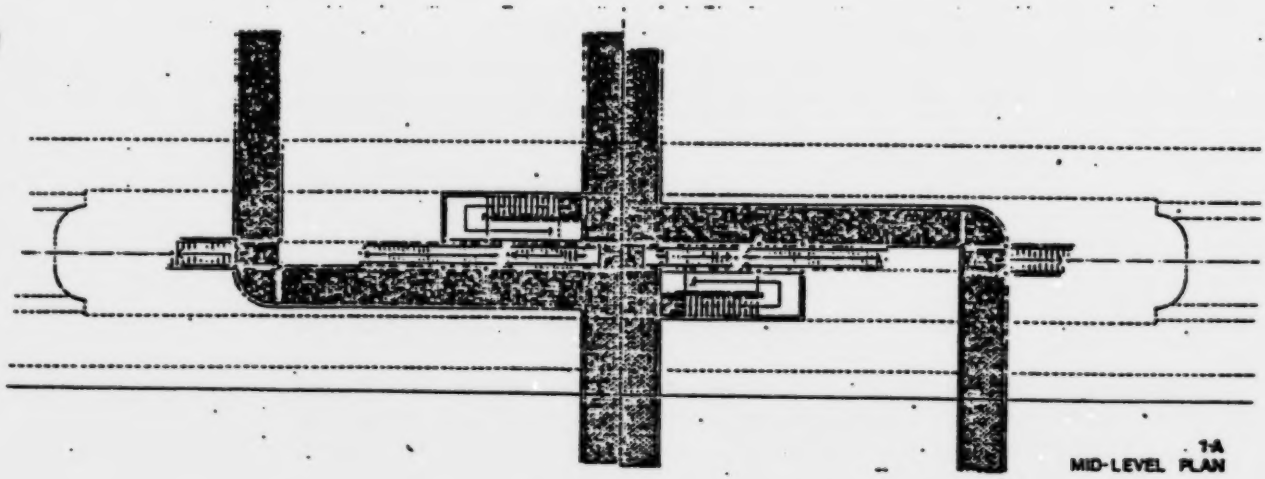
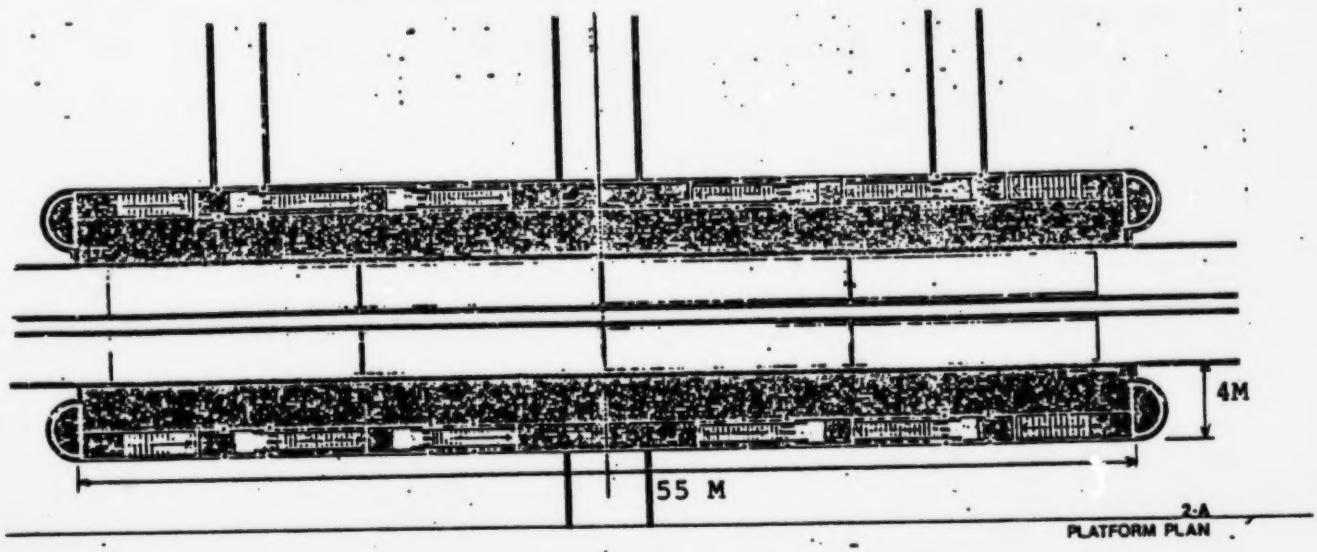


FIGURE 3.2-10

TYPICAL CENTRE PLATFORM STATION



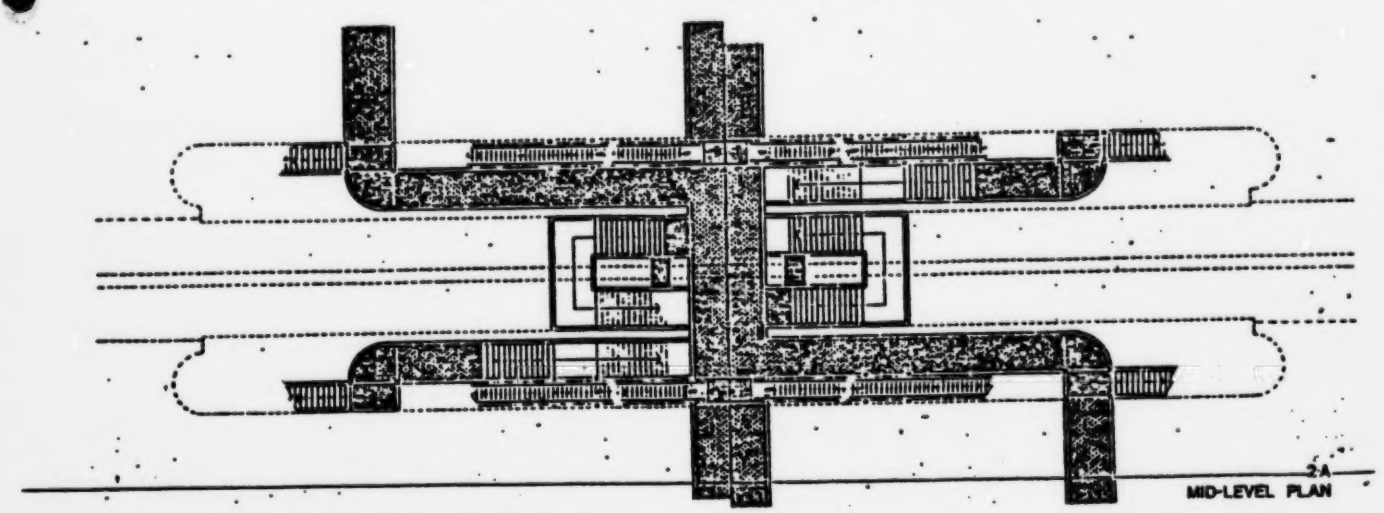


FIGURE 3.3-11

TYPICAL SIDE PLATFORM STATION

The gap between the platform edge and the vehicle will not exceed 63.5 mm. The vehicle floor will always be higher than the station platform. The difference in height will not exceed 40 mm.

A safety line is provided at the edge of the platform.

3.5 Passenger Movement Control

All stations are provided with escalators for transporting passengers quickly and efficiently to and from the station platforms. The escalators and stairs are covered for protection from the weather. Stairs are also provided, next to the escalators, as a secondary method of access to the platform from street level.

Entrance doors to the station are of the two-way swinging type, capable of being locked closed or locked open in the inward swinging position.

3.6 Passenger Information System

Audio and visual information systems are provided at each station to aid patrons in the use of the system. Visual information is in the form of static and dynamic displays.

3.7 Fare Collection Equipment

Fare collection equipment is provided, consistent with customer requirements.

3.8 Miscellaneous Station Equipment

Staff washrooms and observation booths are provided at each station for station attendants and/or inspectors as required. In addition, space is provided for mechanical and electrical rooms. In particular, feed-in devices for the ATC inductive loops are located in a protected environment in passenger stations for ease of maintenance.

3.9 Security Provisions

A closed circuit television system (CCTV) will maintain surveillance of all passenger stations, as described in Section 7. In addition, emergency telephones are provided with direct connection to Central Control.

Each station is provided with security doors capable of securing the station from entry during non-operating hours.

Emergency lighting is also provided.

4.0 MAINTENANCE AND STORAGE FACILITY

4.1 General Description

The following facilities are provided in the maintenance and storage area:-

a) maintenance building;

b) automated storage tracks for entire fleet;

c) transition zone, between automated guideway and maintenance building;

d) interior cleaning and inspection facility;

e) car wash equipment.

4.2 Vehicle Handling

The maintenance and storage facilities are separate entities with respect to the mode of operation and control within each region. Trains in the maintenance area will be manually operated under the guidance of maintenance personnel with no automatic train control. The storage area will, however, be under full automatic control.

The ATC system excludes unauthorized trains from entering the automatic area from the manually operated maintenance area. The change from automatic to manual control or vice versa is accomplished in the "transition" zone. Upon exiting from the revenue system, the ATC system may direct the train directly to the storage area or to the maintenance region. If the train is destined for the maintenance area it must pass through this transition zone. Once this is done, maintenance personnel manually drive the train to any desired location in the maintenance region.

Trains exiting the maintenance area must also pass through the transition zone and are either routed to the storage area or immediately back into revenue service. This decision rests with the central operator. Once the transition or handover track is confirmed available for the manually-operated train, the train is manually moved to the platform in the transition zone. Before a train is accepted by the automatic system, ATC communication and other vital sub-systems are tested for failure-free operation.

If the train passes the acceptance tests, the operator disembarks from the train, and the train is permitted access to the automated areas. Otherwise the maintenance personnel return the train, under manual control, to the maintenance facility.

Trains can enter the storage area either from the maintenance area, after passing through the transition zone, or directly from revenue service. Since all vital subsystems are "on" continuously, trains in storage do not have to be tested prior to their reinsertion into revenue service.

Washing, inspection and internal cleaning of the trains will be done in the storage area. Facilities to perform these tasks are located near the maintenance buildings for easy access by maintenance or other personnel.

A maintenance flow diagram is given in Figure 4.2-12.

4.3 Maintenance Building

The maintenance building accommodates all facilities required for scheduled and unscheduled maintenance and repair of the system. Two maintenance bays are provided, with pits in each bay for access to the underside of the vehicles. Space is provided for mechanical, electrical and electronic workshops and for material storage.

Change rooms, lockers, washrooms and administration offices are also provided in the maintenance building for maintenance staff.

4.4 Maintenance Equipment

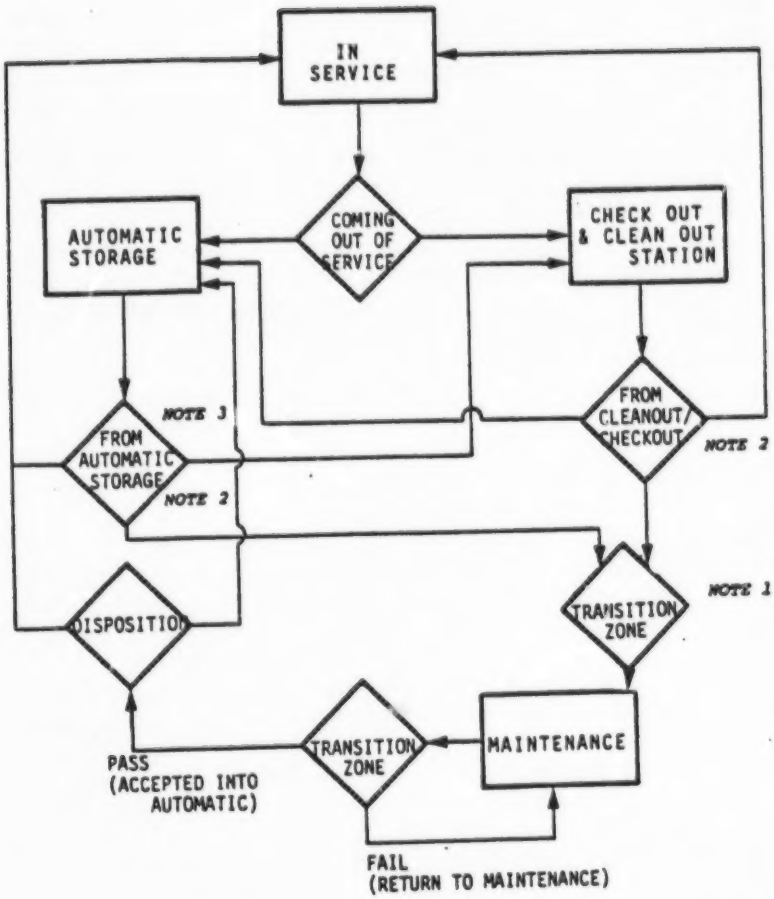
Standard hand tools and standard test equipment are provided for system maintenance. In addition, special test equipment is provided for major vehicle subsystems to assist in fault isolation and equipment check out.

Hoists, jacks and body stands are provided for removal of trucks or axle assemblies and jacks are used for removal of truck parts. A small hydraulic press is provided for replacement of metallastic bearings.

Hydraulic drop tables and a fork lift truck are used to remove undercar equipment packages.

4.5 Security Provisions

The maintenance facility will be completely secured against trespassers. Adequate lighting is provided throughout the maintenance and storage facility.



NOTES:

1) *Trains must pass through the transition zone when travelling to maintenance. Transition performs no function.*

2) *Trains going to maintenance will pick up a driver in the check out/ clean out station in the storage area.*

3) *Trains will be cycled thorugh the check out/ clear out station once a day. They may be drawn from and returned to storage.*

FIGURE 4.2-12

MAINTENANCE FLOW DIAGRAM

5.0 VEHICLE

5.1 General Description

The basic operating unit for the system is a semi-permanently coupled married pair of vehicles. Each vehicle is motored and has a unique identification. The married pairs are capable of coupling into four car trains for peak hour operation. Each end of each married pair is equipped with an automatic coupler incorporating an electrical head.

Each vehicle is supported by two double axle, steerable, steel wheel trucks, employing an elastomeric suspension system.

Propulsion is provided on each vehicle by two linear induction motors (LIMs) and their associated power conversion units (PCUs). The LIMs, suspended from the truck, supply propulsive force through electro-magnetic interaction with a reaction rail mounted on the guideway between the running rails. The PCU conditions the nominal 600 Volts Direct Current (VDC) wayside power to a variable frequency, variable voltage, 3 phase AC output for use by the LIMs.

The braking system on each vehicle employs three subsystems. Service braking forces are supplied by means of the LIM propulsion system, independently of the wheel rail interface. This is supplemented when required by the spring applied hydraulic disc brake system which also supplies the parking brake function. Electromagnetic track brakes are used in conjunction with the disc brake system to supply emergency braking forces.

The vehicle electrical system consists of a 37 volts DC supply for low voltage functions and 600 VDC for propulsion and other high voltage systems. The 37 volts bus is supplied by a DC/DC converter which draws power from the 600 VDC supply. A 37 volt battery supply provides power to critical subsystems in case of loss of the primary 37 volt supply.

Power is collected from the wayside by means of power collectors mounted on each truck. A set of collectors is mounted on each side of each truck.

The vehicle body is of aluminum construction with fibreglass end caps. Vehicle equipment is mounted in the end caps, under seats, and under the vehicle floor. No vehicle air conditioning will be provided, however the vehicles will have forced air ventilation and heating.

Two service doors are provided on each side of each vehicle. Each door consists of two bi-parting panels of outside sliding design. The clear width of each door opening is 1.22 m allowing two passenger lanes per door. A crush-loaded vehicle can be completely unloaded at a station platform in less than one minute. Nominal opening and closing times are 1.5 seconds opening time and 2.5 seconds closing time. An automatic audible signal is provided prior to door closing.

A crew switch is provided on the inside and outside of the vehicle. This switch is operated by a special key and is used by maintenance and cleaning crews to gain access to vehicles and to hold automatic vehicles stationary. An open door ensures that vehicle motion does not occur.

Push buttons (interior and exterior) for selective door operation may also be provided as an option. A particular door will only open if the button has been pressed and the door open command from the on-board control system is in effect.

In the event of a door operator failure or a failure of the door status indicator a maintenance man can manually close the door and disable the door operating mechanism. A manual lock is provided within the door mechanism to ensure that the door stays secure. The locked door provides a door closed signal to the on-board control system and enables the vehicle to continue operating until it can be taken out of service.

A suitably protected emergency release lever located near the doors can be used by a passenger to disengage the normal door locking mechanism. Operation of the lever interrupts the door closed status signal. Similar levers are located on the outside to provide for emergency access into the vehicle.

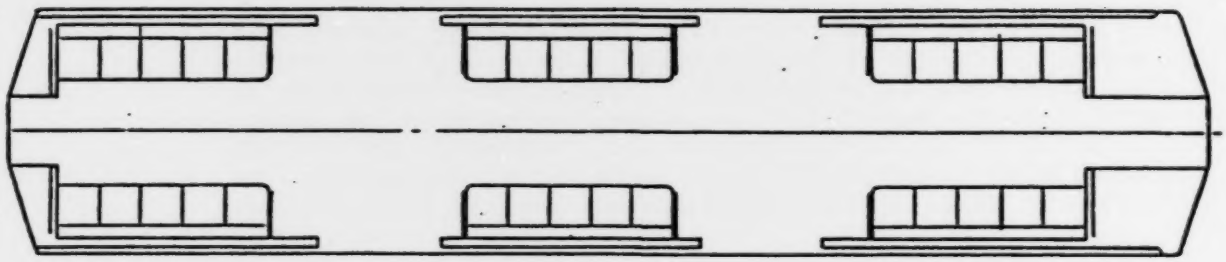
Doors are provided at each end of the vehicle to allow access for maintenance staff and for emergency passenger egress from one car to another or down to the guideway. These doors are hinged and open inwards. The door release is suitably protected to deter mischievous use.

5.2 "Vehicle Layout"

Major dimensions of the vehicle are listed below:

Length of vehicle (over coupler faces)	12.700 m
Width of vehicle (maximum)	2.500 m
Height of vehicle (top of rail to top of roof)	3.125 m
Top of rail to vehicle floor top surface	0.778 m
Interior height, floor top surface to headlining	1.980 m
Interior width	2.200 m
Interior length of passenger compartment	10.548 m
Width of side door openings	1.220 m
Height of side door openings	1.930 m
Height from floor to bottom of side windows	0.980 m
Height from floor to top of side windows	1.830 m
Distance between truck centers	7.940 m

A typical interior layout of the passenger compartment and the seating configuration is shown in Figure 5.2-13. A perimeter seating arrangement is illustrated; however alternate configurations with transverse and longitudinal seats are available and have only a marginal effect on design and performance. An allowance of 0.41 m^2 per seated passenger and 0.23 m^2 per standee gives the following capacities:



SEATING PLAN

30 SEATED 45 STANDING

FIGURE 5.2-13
CONFIGURATION OF PASSENGER COMPARTMENT AND SEATING

	Per Vehicle	Per Married Pair
No. of seated passengers	30	60
No. of standees	45	90
Total	75	150

For operational considerations, the crush capacities at 1.6 times the nominal standing capacity are:

	Per Vehicle	Per Married Pair
No. of seated passengers	30	60
No. of standees	70	140
Total crush capacity	100	200

Final selection of the interior design and finishing materials will be in accordance with the requirements of the Hamilton/Wentworth specifications and in consultation with the customer.

5.3 Performance Data

For performance purposes, the empty weight of each vehicle is assumed to be 13,600 kilograms which results in an assumed vehicle weight of 18,850 kg at nominal capacity.

Acceleration rates are controlled by the on-board control system and are limited by passenger comfort criteria. When vehicles are accelerating on grades, the grade effect is compensated for in the acceleration profile.

Under normal operating conditions, vehicle deceleration rates are controlled to a constant value. In areas of the guideway where normal deceleration rates are difficult to achieve, an alternate lower braking rate may be specified.

5.4 Vehicle Controls

The propulsion, braking and door subsystems are under the control of either a Vehicle On-Board Controller (VOBC) or a hostling panel. For all normal operations, the vehicle will be under the fully

automatic control of the VOBC, which is described in Section 8. No vehicle operator is required. The control system provides for an automatic switchover between two VOBCs on a train in case of a VOBC failure. The hostling panels will be used for vehicle movements in the non-automated sections of the maintenance yards and for recovery operations, where possible.

Each married pair is equipped with a hostling panel at each end. Each panel permits manual driving in the forward direction only and the panels are locked out when the car end is coupled to another consist. The panels are equipped with key locked protective covers and a function enable/disable key to activate or deactivate the panel. Activation of the panel locks out automatic operation. In manual control the trains are governed to a maximum speed of 16 km/h and the panel is provided with a "deadman" interlock feature to increase operational safety under manual operation.

Each vehicle is equipped with a Health Monitor System (HMS) to provide a readily accessible record of degradation and failures in critical vehicle subsystems. Diagnostic data derived from the HMS will assist in vehicle maintenance and repair.

5.5 Safety Features

The vehicle design provides all the features required for acceptable, safe operation in a North American transit system. These features include the use of non-flammable or fire resistant materials, crashworthiness provisions, safe door operation, an automatic train control system and an emergency brake system.

Materials used in the vehicle design are selected to meet industry guidelines for flammability and smoke emission, and fire barriers are provided to isolate equipment compartments from the passenger cabin. Temperature sensitive detectors are incorporated into all major equipment bays and photoelectric smoke detectors are installed in the passenger compartment of each vehicle. These sensors activate an alarm to Central Control and the train will be automatically routed to the next downstream station and held there with its doors open. Each vehicle is equipped with a portable dry chemical type fire extinguisher.

The structure of the vehicle ends is designed to include passenger free space and to crush in a predictable manner in the unlikely event of a collision.

The vehicle interior is designed to minimize passenger injury from protrusions, sharp edges and other hazards arising from sudden stops, and hand assists are provided for the convenience and safety of standing passengers and those who are moving to and from a seat.

The passenger doors are equipped with sensitive leading edges to arrest the door closing in case an obstructing object is encountered, and the door operator incorporates a push back feature so that small objects, items of clothing, etc., may be pulled through the door when closed. Safety interlocks are provided within the on-board control system to inhibit vehicle departure from a station unless all doors are closed and locked. Provisions are made for a manual override of the power door operation for the purposes of opening a closed door in an emergency situation. Such manual override is accessible by positive passenger action from both inside and outside the vehicle. End doors are provided on each vehicle to provide for emergency passenger movement between vehicles, and for emergency egress to the guideway.

In response to commands from the wayside, the on-board control system ensures that the train does not exceed the guideway-oriented velocity profile, and that a safe distance is maintained between successive trains. The control system immediately causes the train to come to a stop in the event of overspeed, rollback, loss of train integrity or any lack of assurance of safe vehicle movement. The emergency braking system ensures that the vehicle stop occurs within the assured clear distance under all specified operating conditions. These conditions specifically include all guideway grades and the condition resulting from a "full forward" failure of the propulsion mechanism.

Under certain conditions, and with full train protection, the emergency brake system can be reset remotely via the ATC system.

Electrical safety of the vehicle is assured by grounding the body shell to the running rails via axle brushes and wheels. Two independent grounding

circuits are provided in each vehicle. The running rails are periodically connected to ground.

5.6 Security Features

Each married pair is equipped with a two way radio system, for communication to and from the wayside. The radio provides emergency communication for passenger use and also establishes a wayside to vehicle audio communication facility for broadcasting annoucements over the vehicle public address. A full description of the vehicle public address and the vehicle two way radio system is given in Section 7.

A passenger assistance alarm strip is also provided on each vehicle. These strips will activate an alarm to the Central Operator.

An emergency stop handle will be located in the passenger compartment and will be identified with a penalty for misuse warning displayed also. Actuation of the handle will:

a) immediately stop the train if the speed is not in excess of 2 m/sec. and central control will be alerted. Reset action will be required before train is permitted to leave the station.

b) if speed exceeds 2 m/sec. central control will be alerted and reset action will be required before train is permited to leave the next station.

5.7 Vehicle Onboard Attendants

While ICTS is a fully automated system capable of safe, unmanned operation, an on-board non-driving attendant option has been retained. Duties of the attendants will require customer definition.

6.0 POWER SUPPLY AND DISTRIBUTION

6.1 General Description

The power distribution system distributes power at the required levels and ratings for utilization by vehicles, passenger stations, maintenance and storage area facility and the control centre.

The system is supplied from two independent sources.

There is sufficient redundancy designed into the traction power supply system to ensure that no single point failure will preclude system operation.

6.2 Traction Power Substations

Traction power substations are located at or near heavy demand, critical stations to provide the necessary voltage for maximum performance capabilities. Power substations for ICTS are separate from those feeding the trolley bus overhead.

Each traction power substation consists of the following equipment:-

a) AC switchgear;

b) Transformer/rectifier unit;

c) DC switchboard;

d) Regenerative braking resistor unit;

e) Batteries and battery charger;

f) Transformer unit;

g) Distribution panelboard;

h) Accessories and miscellaneous equipment.

Under certain operating conditions, when the energy regenerated by decelerating vehicles cannot be absorbed by other vehicles in the system, the power rail and feeder voltage will tend to rise. Therefore, a unit is provided at each substation which senses increasing voltage and switches an outdoor, self-cooled resistor unit into the circuit.

The traction power substations also contain the equipment necessary for the distribution of the power for station services. The layout of the substation provides easy access to all equipment for removal or maintenance purposes. An entrance/exit door and an emergency exit door are provided on opposite walls.

6.3 Wayside Power Distribution

The 600 V dc is distributed from the dc switchboard of the traction substations to the wayside power rails by dual cables.

Dual power rails at positive and negative potentials with respect to ground are provided continuously along the guideway. These rails are of aluminum construction with contact surfaces of stainless steel. The power rails are insulated from one another and from ground by fiberglass reinforced polyester clamps which also serve to locate the rails to the required tolerance. Expansion joints are located periodically along the power rails.

6.4 Supervisory Control

A supervisory control panel is provided in each traction substation for the equipment therein. In addition, the Control Centre is provided with a master supervisory control panel for the equipment in all substations.

6.5 Power Cut-off System

The wayside power supply is normally controlled remotely from the central control room. There is also the capability to de-energize the system sections locally from the traction power substations. Power cut-off system switches will be located at frequent intervals throughout the guideway. These switches will remove traction power from the power rail in both directions. In addition, power cut-off switches located in passenger stations will incorporate a device which, when activated, will automatically prevent approaching trains from entering into a station and its immediate surrounding guideway. Vehicles which are in this zone, or about to enter it will be emergency braked. The box locations are identififed by a blue fluorescent lighting fixture. Also located at each box is a "hot line" telephone connected directly to the control centre.

Power restoration procedures will ensure that power cannot be restored to the guideway until the scene of the incident has been visually inspected.

6.6 Power Rail Heating

The traction power substations throughout the system each feed an approximately equal length of power rail heating element. Automatic remote control of the heating system is provided.

6.7 Standby Power Supply

In the event of an area-wide power outage, a diesel generator set can be connected to the traction power feeders to serve as a standby power supply. This enables evacuation of the system by moving the trains to their next passenger station. The standby power supply permits the movement of one train at a time, at reduced speed, while maintaining the essential services in the remaining vehicles.

Essential equipment loads, such as vehicle control computers, voice communication equipment and emergency lighting are supplied from an uninterruptable power supply, using batteries capable of supplying power to the critical loads for a period of at least one hour.

6.8 Facilities Power

The maintenance and storage facility is supplied with power from a traction power substation. In the maintenance and storage yards, power is distributed to the vehicles by regular power rails. In the maintenance building, 600 V dc is provided to the vehicles from insulated overhead cables which plug into receptacles on the vehicle.

Power for all other facilities and services associated with maintenance facility, stations and guideway is obtained from circuits separate from those of traction power.

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7.0 VOICE AND VIDEO COMMUNICATIONS

7.1 General Description

A comprehensive communications network is provided, covering normal day to day operations, emergency operations and passenger distress situations. The communication network comprises both radio and hard-wired links.

7.2 Public Address System

All stations and vehicles are equipped with a public address system permitting the broadcast of prerecorded and/or live announcements. The station public address system covers the fare areas and station platforms and is direct-wired from the control centre. Stations and station areas may be addressed individually, collectively or in combination with vehicles.

The public address system in the vehicles is used to make announcements in the event of an emergency or delay. Patrons are informed of the nature of the problem and advised of the expected duration of the delay and/or the procedures to follow.

7.3 Emergency Telephones

An emergency telephone is located on each platform of every station. These telephones are for emergency use only and appropriately labelled. The phones are direct-wired to the control centre. Activation of the emergency phones results in an immediate alert signal to the central operator accompanied by a display of the telephone location identification.

An emergency communication system is also provided between tunnel and surface locations.

7.4 Vehicle Radio

Each vehicle is equipped with a two-way radio, which will be available to patrons in distress situations. The radio facility provides the passengers with the means to request a two-way speech link between the passenger and the central operator on a separate, reserved radio channel. To ensure operational availability under primary power failure, the on-board radio system is fed through the vehicle's emergency power system.

7.5 Closed Circuit TV (CCTV)

A closed-circuit television system is provided to permit security personnel to monitor passenger activities at all stations in the system. Television cameras cover:

a) fare collection areas;
b) escalators and stairs;
c) platform areas;
d) other special areas.

CCTV monitoring equipment is located in the central control facility. To enable the operator to view the monitors efficiently, only one monitor per station is provided. Since more than one camera per station is required to provide adequate coverage, a sequential scanning arrangement is used to permit display of each camera on the monitors. TV cameras are located to provide an overall view that permits detection of unusual or criminal activities. To aid security personnel, alphanumeric station/camera identification is provided with every monitor image.

Each TV camera is of the low light level type to ensure useful pictures even under station emergency lighting conditions.

All cameras have remotely controlled zoom capability and vandal resistant construction. To maintain system security under conditions of primary power failure, the closed-circuit video surveillance system is fed from the uninterruptable power supply.

7.6 Maintenance Facility Communications

A two-way radio system will be used for communication between the following areas: control centre, maintenance facility building, washing and cleanout area, and the vehicle storage area.

7.7 Security Radios

Security personnel will be equipped with portable radios. A separate security radio channel will be reserved to permit uncontested access to the communication facility.

8.0 AUTOMATIC TRAIN CONTROL

8.1 General Description

The ICTS train control system is based on the SELTRAC automated system developed by Standard Elektrik Lorenz (SEL). The system is a computer based, moving block system with inductive loop communication between the wayside and vehicles. The system is developed around three basic levels of control as shown in Figure 8.1-14.

With the high resolution of the SELTRAC position detection system, a following train may safely close up to a point which is a safe braking distance from the last verified postion of the rear end of a preceeding train. This results in a significant reduction in minimum system headway relative to conventional, fixed-block control systems. In addition, the moving block concept provides improved operational flexibility for coping with variations in station dwell and vehicle malfunctions.

8.2 Systems Management Centre

The Systems Management Centre (SMC) is a computer based facility which has primary responsibility for automatic train supervision (ATS) functions, including schedule control, traffic regulation, operator interface and corrective strategy implementation. All routines dealing with established operating procedures operate automatically via the SMC but may be altered by intervention of the Central Operator (CO). These routines include functions such as routing, scheduling and other normal train control procedures. Failure management, system start-up/shut down, train insertion/removal, and other special procedures require interaction with the CO. Information exchange between the SMC computer and the CO is accomplished by means of video display terminals, line printers and colour graphics.

8.3 Vehicle Control Centre

The Vehicle Control Centre (VCC) is a checked redundant mini-computer configuration, responsible for the safe control of vehicle and switch movements. The computer configuration is realized as a triple comparison scheme whereby any combination of two computers must agree before a command is output. If one computer should fail, the other two can carry

on operations until the failed computer is repaired or replaced.

Communications between the VCC and vehicles is by inductive coupling. Loops, fed from the VCC, are laid along the guideway and antennas mounted on the vehicle trucks inductively coupledto the wayside loop. Loss of communication to a vehicle does not create an unsafe condition. Since each message to the vehicle contains a "guaranteed safe" target point, the vehicle will stop at this position until communication is restored.

The VCC monitors the position of all vehicles and the status of all switches. The safe target point for each vehicle is determined by the VCC for the most restrictive of the following conditions:

a) last verified position of a preceding vehicle;

b) unlocked switch;

c) velocity restriction; and

d) station stop.

8.4 Vehicle On-board Control

The Vehicle On-Board Control (VOBC) equipment comprises a checked-redundant micro processor based system which implements all vehicle control functions, in response to the wayside commands. These functions include longitudinal control, door control and safe travel verification. The VOBC supervises the velocity of the vehicle within the limits imposed by the VCC and an automatic speed control algorithm exercises control over the propulsion and braking systems to achieve the desired vehicle performance.

In the event of failure of the VOBC, automatic switchover to a second VOBC in the train will be initiated from the wayside control. This results in high operational reliability of the on-board control system.

8.5 Switch Control System

The switch control system comprises interface units to the VCC, railroad type electro-hydraulic switch machines and a manual switch control panel. The

interface units decode individual switch movement commands to the switches from the VCC (or manual control panel) and relay status data from the switches back to the VCC.

The VCC prevents a train's entrance into a switch zone until the switch is reserved for that train and the switch status is correct. It does this by holding the train's stopping point a safe distance in front of the switch, until such time as all conditions are fulfilled.

Switches may be manually set by the Central Operator from the manual switch control panel in the control centre, but the VCC inhibits operation of the panel once a switch zone has been reserved by a train.

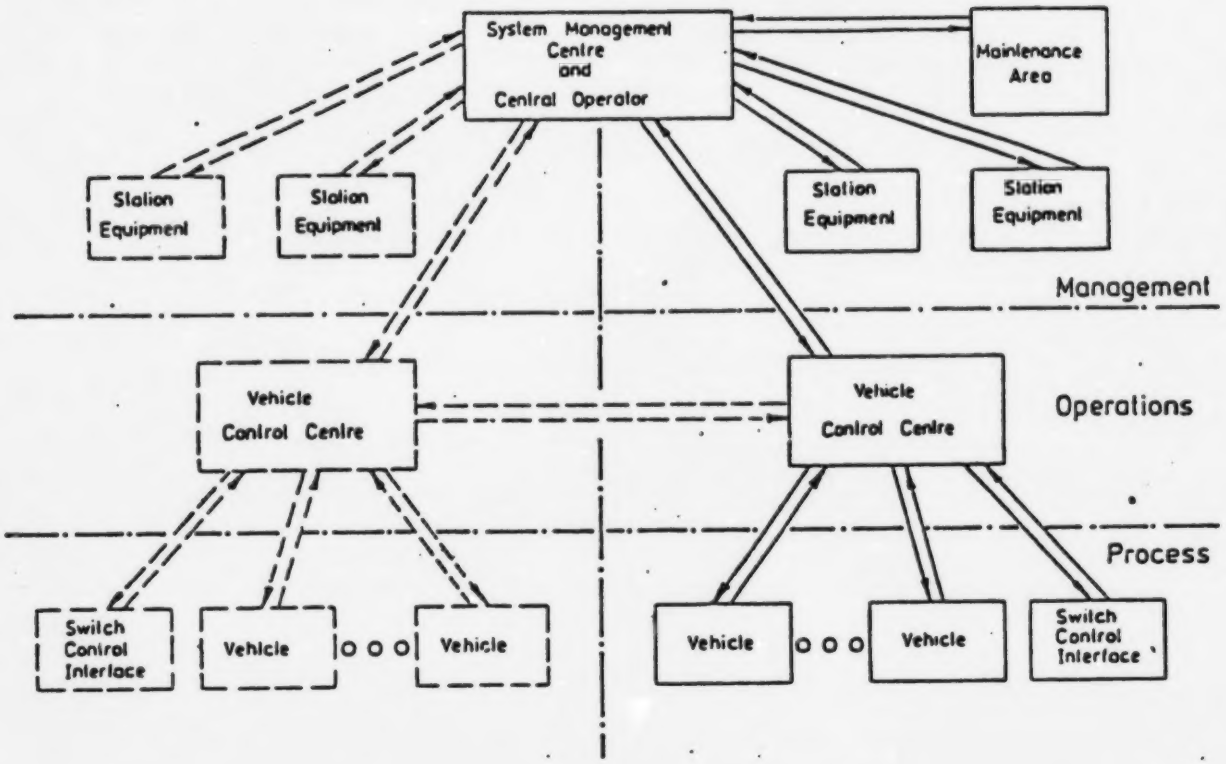

FIGURE 8.1-14

TRAIN CONTROL SYSTEM STRUCTURE

9.0 CONTROL CENTRE

9.1 General Description

The Central Control Facility is designed for two man operation but laid out in such a way that one operator can readily undertake all the Central Operator (CO) functions for a period of time if necessary. A guideway schematic display is provided to offer a visual representation of real-time operating conditions throughout the system. A Power Schematic Display is integrated into the console with the control and monitoring equipment.

The following central operator equipment is located in the control centre:

a) ATC console,

b) guideway schematic display,

c) guideway switch mimic and control console,

d) power supply system control console and dislay,

e) voice communication system console,

f) closed circuit TV control console and monitors.

9.2 Central Operator Console

The Central Operator (CO) console incorporates the guideway schematic display and vertically mounted control panels, with a horizontal ledge for the keyboards and control equipment. Certain key facilities, such as telephones and announcer stations are duplicated so that either operator may use the equipment.

Under normal circumstances, one operator will be responsible for the automatic train control system operation and the other operator will be responsible for communications and auxiliary systems supervision and control. Since all normal train movements are fully automatic, the operators will be free to devote most of their time to the supervision of the system.

For system failures the CO will receive immediate information about the type of failure, the location of the failure and other pertinent information, such as train identity. Audio and visual alarms are provided to alert the operator. All performance

control functions related to the normal operation of the system as well as all required performance override functions can be performed by the CO.

9.3 Guideway Schematic Display

The guideway schematic display provides the CO with a quick, visual assessment of system status. The display contains a permanent, graphical representation of the guideway system, stations, switches, and storage area. The display includes the following visual information:

a) location of all active vehicles in the system,

b) position of all system switches,

c) operational mode.

9.4 Guideway Switch Mimic and Control Console

To permit remote switch setting by the operator a special guideway switch mimic, equipped with specially interlocked push-buttons, is provided. Two push-buttons must be simultaneously activated before a switch-setting command is accepted. The panel settings override the VCC although the VCC retains responsibility for safe train movement through the switch.

9.5 Power Schematic Display and Power Control Equipment

The Power Schematic Display gives operators the capability to monitor the operation of the power supply system throughout the system. The display includes the following:

a) segment by segment status of guideway electrification,

b) status of all switchgear,

c) status of the emergency power system.

The operator is able to control the application and removal of power to each separate segment of the guideway.

9.6 Voice Communication System Interface

An integrated voice communication system provides the vital interface between the CO and:

a) system patrons in vehicles and/or in stations,

b) public safety and fire departments,

c) manual vehicle operators,

d) maintenance personnel.

Identical announcer stations are provided at each operator position. Each announcer station may be used to broadcast annoucements to stations or to individual trains or vehicles or to make system wide annoucements.

Radio communication facilities are provided to permit two-way voice communication between the CO and:

a) passengers requesting assistance,

b) public safety and fire departments,

c) security personnel.

Passenger-initiated voice communication requests from a vehicle automatically activate the radio link between the CO and the vehicle. Together with the voice communication request, the CO receives a display of the identity and the location of the vehicle from which the request has originated.

A voice recording device is furnished for recording all voice communication exchanges.

A system telephone network is also provided for emergency use and for operational procedures between central and the rest of the system.

9.7 Closed Circuit TV Interface

Closed Circuit TV coverage is provided for:

a) fare collection areas,

b) escalators and stairs,

c) platform areas.

There is one monitor for each of the stations. Under normal operation the station cameras sequence through their respective station monitors in a preselected logical order. A video recorder with one hour continuous recording capacity permits recording from any camera in the system.

10.0 APPENDIX A TO THE SYSTEM OPERATING REQUIREMENTS

CUTA Policy on Transportation for the Handicapped

1. Introduction

With the increased affluence of the past three decades, Canadians have come to enjoy a very high level of transportation service. The jump in auto ownership, widespread road construction, and the use of public funds for transit have resulted in a situation where most of us can take freedom of movement for granted.

However, there is one group that has not been able to take full advantage of these benefits: those who are physically handicapped. Many of the handicapped do not drive, and have great difficulty in using public transit. Those who are restricted to wheelchairs have perhaps the most acute hardships in obtaining transportation, and must often use special vehicles at considerable expense.

In a country as affluent as Canada, fairness would seem to dictate that the physically handicapped should have reasonable access to the diversity that our society offers, including employment and community activities.

2. A Diversity of Requirements

Although precise data are not available, it is estimated that 7% to 8% of Canada's population have disabilities that restrict their freedom of movement - about 1.5 million people. There is a wide spectrum of disabilities within this group. Some can use the existing public transit systems, while others require extensive special assistance.

Some general categories of disability are as follows:

- About half of the 1.5 million can use existing transit services without too much difficulty.
- Another 400,000 have handicaps such as problems in climbing steps, which allow them to use transit but with significant effort.
- About 300,000 cannot use the existing transit system at all, but can be driven in automobiles.

- About 50,000 individuals can conveniently travel only in a special vehicle that can accommodate wheelchairs.

From this diversity of requirements, one can see that a range of solutions is necessary. The needs of each specific group should be met in the ways which best alleviate their particular problems.

3. A Basic Principle

The Canadian Urban Transit Association accepts the principle that physically handicapped people require affordable and convenient transportation to enable them to work and to participate in everyday community activities. Providing this mobility will require public financial assistance, and the necesary funds should be made available by the federal, provincial, and municipal governments. However, in this time of financial constraint, it is important that any such funds be used in a way that will provide the greatest help for those whose need for transportation assistance is most acute.

As most people who have examined the issue are aware, transportation for the handicapped involves far more than the provision of the service itself. Land use planning is involved, to ensure that housing for the handicapped is close to potential employment locations. Special parking policies can help those handicapped people who are able to drive. Accessibility within buildings is another issue. While acknowledging the importance of all these other areas, this CUTA position paper concentrates on the provision of the actual transportation service itself.

4. The Fundamental Options

The most controversial policy issue in providing transportation service for the handicapped in our cities concerns the people who have the greatest need: those confined to wheelchairs. One viewpoint holds it that existing transit services should be made fully accessible to people in wheelchairs through the provision of ramps, elevators, and lifts, while others argue that they should be provided with a special customized service using appropriate vehicles, on a demand-responsive basis.

This is an emotional issue, and has become a point of principle. A parallel service is seen by some handicapped people as less desirable than integration with the system that everyone else uses, and this is understandable. However, in terms of the actual mobility provided to the wheelchair-bound patron, it has been shown that a specialized demand-responsive system can provide better access to the community than major modifications to the existing service could, especially when relative costs are considered.

The American Public Transit Association and the International Union of Public Transport have recommended that the transit needs of people in wheelchairs should be met by demand-responsive special services, and this is becoming accepted practice. Existing transit systems must also be modified where feasible, but not at the expense of special services for those with the greatest needs.

The American Public Transit Association has expressed its position as follows:

> **APTA believes that the Section 504 prohibition of discrimination against handicapped persons requires that community mobility for the nonambulatory handicapped be provided. APTA believes that mandatory accessibility on regular transit routes would fail to be cost-effective, and would not provide the sough after mobility.**

A report to the International Union of Public Transport at its 1977 meeting in Montreal stated as follows:

> **The survey of transport undertakings shows that practically all of them agreed that the disabled (especially severely disabled persons confined to wheelchairs) should not be carried by the ordinary public transport system. The dial-a-bus system probably has a major role to play in this special transport task, because of its relatively high transport quality, flexibility, and the possibility of carrying people all the way from origin to destination which such systems can offer. Specially-equipped vehicles will of course be needed in this case.**

The controversy surrounding the issue of full accessibility versus parallel service is unfortunate in that it has tended to obscure the need for less drastic modifications to existing transit systems so that those with less serious handicaps can use them more easily.

As shown earlier, the majority of handicapped persons can use the existing transit services, but with varying degrees of difficulty. Existing transit systems should be provided with funds to carry out necessary improvements, such as reserved seating near vehicle doors, more stanchions, railings, and handholds, escalators (in systems that have subways), and facilities for making stop announcements for the blind. There is probably a significant opportunity for increased ridership in this area if the necessary improvements are made.

Among the handicapped who cannot use transit even with such modifications, the majority do not need special vehicles: they can be driven in automobiles, or they can even drive automobiles equipped with special controls. the best solution for these people seem to be subsidized taxi services, a system which has been very successful in Sweden. Subsidies for specially-equipped automobiles should also be considered.

5. Transportation for the Handicapped: CUTA's Proposals

The Canadian Urban Transit Association accepts the principle that physically handicapped people in Canada urgently require affordable and convenient transportation. In fulfilling this principle, CUTA recommends that a range of service improvements be made, with each service tailored to the needs of people with a specific type of handicap. CUTA cannot recommend the approach of modifying existing transit systems to accommodate wheelchairs; it would be by far the most expensive solution, and would probably provide lower accessibility than other options.

The Canadian Urban Transit Association urges that the following steps be taken to provide mobility for the handicapped:

- That the federal, provincial and municipal governments provide adequate funding for the provision of demand-responsivle special vehicle

services for individuals who are restricted to wheelchairs.

- That subsidized taxi or regular automobile services be made available to supplement these demand-responsive special vehicle services for those disabled individuals who do not require wheelchairs but are not able to use conventional transit facilities.

- That Canadian transit systems be provided with subsidies to improve the accessibility of the existing transit facilities to those who can presently use it only with great difficulty, for instance by providing special seating, handrails, additional escalators (in systems that have subways), and equipment for making stop announcements.

- That the feasibility be studied of subsidizing specially-equipped automobiles for those disabled individuals who would be able to drive them.

- That CUTA members take a lead role in the development of a standard design for vans for the handicapped, in setting up special services in their communities, and in providing direction to any private contractors who are providing transportation services to the handicapped.

- That CUTA members assist the taxi industry in the design of specially equipped taxicabs capable of accommodating the needs of those disabled individuals who do not require special lift devices but are not able to use conventional transit facilities.

- That CUTA members assist service clubs and other organizations active in providing transportation for the handicapped by supplying technical information--on vehicles, dispatching systems, operating costs, and available funding support programs.

- That CUTA act as a clearing house on operator experience with respect to special services for the handicapped.